Chemistry for Medicine

25 December, 2012

Chem2110 Test 4

TIME: 1¾ Hours

NAME: MARKING GUIDE **ID NUMBER:** ____________

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La*** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226	89 **Ac†** (227)															

Question	Maximum Marks	Score
1	64	
2	46	
Total	110	

$N_A = 6.022 \times 10^{23}\ mol^{-1}$

$1\ amu = 1.6605 \times 10^{-24}\ g$

$K_b\ (NH_3) = 1.78 \times 10^{-5}$

(32)

Question 1

Complete the following statements:

(a) A solute dissolves in a solvent to give a homogeneous mixture. If the dissolution occurs in water the mixture is called an aqueous solution

Water dissolves ionic compounds and polar covalent compounds

(b) The reaction between potassium hydroxide and formic acid is called neutralization or acid-base reaction. The net ionic equation for this reaction is $HCOOH(aq) + OH^-(aq) \rightarrow HCOO^-(aq) + H_2O(l)$

In this reaction the potassium ion is the spectator ion

(c) A strong electrolye dissociates completely in water to give a solution that strongly conducts electricity.

The SI base unit of electric current is Ampere.

(d) Whereas lactic acid is monoprotic, oxalic acid is diprotic

Whereas sulfurous acid is weak, sulfuric acid is strong

Whereas $H_2C_2O_4 \cdot 2H_2O$ is hydrated, $H_2C_2O_4$·[redacted] is anhydrous

(e) The conditions for the most effective buffer solution are as follows:

the desired pH must be as close as possible to the pKa of the weak acid

* presence of a weak acid/base and it conjugate base/aci

*the weak acid/base and its conjugate base/acid must be present in equal amounts

*the weak acid/base and its conjugate base/acid must be present in large quantities

(f) The pyruvate ion is the conjugate base of pyruvic acid.

(g) The mass of a substance with four decimal places is measured using an analytical balance

(h) When zinc reacts with hydroiodic acid, a gas is produced. We can also say that a gas is evolved, given off or released

The name of this reaction is redox and the net ionic equation for this reaction is $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

(i) The acidity of a solution can be shown by any of the following:

litmus paper, universal indicator paper, indicator, pH meter

However, most accurate measurements of acidity of a solution are given by

pH meter

(j) Two examples of functional groups of acidic organic compounds are

carboxylic acid and phenol

(k) In a dilution, the number of moles of the solute remains constant, but

volume of the solution increases and the molarity of the solution decreases

The solution that is diluted is called a stock solution .

(l) When nitrous acid is mixed with pure water it dissolves completely and but dissociates only partially to give a small amount of H_3O^+ and NO_2^-

(m) The solid product formed when two solutions are mixed together is called

a precipitate

(n) When chlorine gas absorbs UV light its single bond breaks in a chemical process called photodissociation . The product of this reaction is a free radical ($2\cdot Cl$)

(o) The equivalence point of an acid-base titration is the point at which stoichiometric amounts of the acid and the base have reacted completely

(p) The lower the pH of a solution the higher the concentration of the hydronium ions and the greater the acidity of the solution

(q) The lower the pK_b of a base the larger the K_b value for the base and the stronger the base

(r) A proton is an electron-pair acceptor; a base is a proton acceptor

(s) Four examples of strong bases are OH^-, H^-, NH_2^-, O^{2-}

(t) K_w is the dissociation constant for water

(u) Phenolphthalein is an acid-base indicator

Question 2

(a) Draw a simple diagram that shows how a titration is carried out in the laboratory.

(4)

(b) Explain briefly the pH of a solution at the equivalence point of a strong acid and a weak base. *Do not give any example.*

At the equivalence point the solution will contain a neutral conjugate "base" of the strong acid and an acidic conjugate acid of the weak base. Thus the solution will be acidic and the pH will be below 7.00. (3)

(c) A special equation is used to calculate the pH of a buffer solution.

What is the name of this equation? Henderson-Hasselbalch equation
Derive this equation. (1)

(2)

(e) When mercury(I) ions are added to a solution of aluminium bromide in water a solid is formed.

Give a net ionic equation for this reaction.

$$3Hg_2^{2+}(aq) + 2AlBr_3(aq) \longrightarrow 3Hg_2Br_2(s) + 2Al^{3+}(aq)$$

$$3Hg_2^{2+}(aq) + \cancel{2Al^{3+}}(aq) + 6Br^-(aq) \longrightarrow 3Hg_2Br_2(s) + \cancel{2Al^{3+}}(aq)$$

$$\cancel{3}Hg_2^{2+}(aq) + \overset{2}{\cancel{6}}Br^-(aq) \longrightarrow \cancel{3}Hg_2Br_2(s)$$

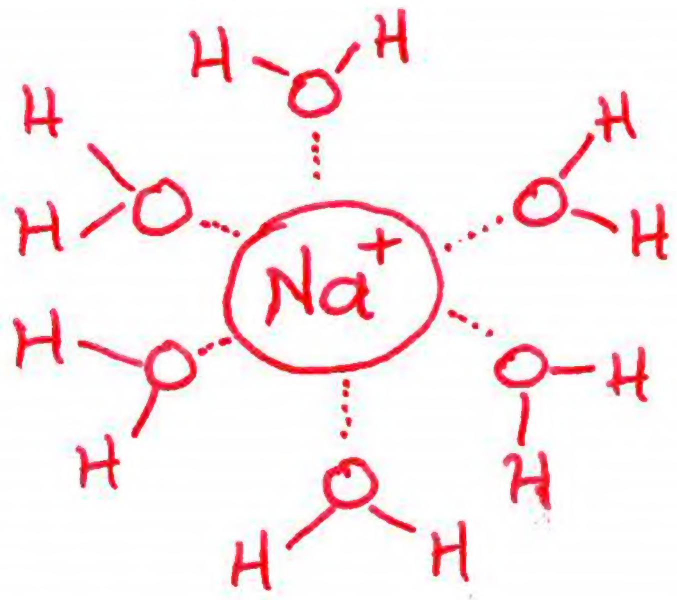
(3)

$$\Rightarrow \quad Hg_2^{2+}(aq) + 2Br^-(aq) \longrightarrow Hg_2Br_2(s)$$ NET IONIC EQUATION

(f) Describe and explain in detail what happens when sodium acetate is mixed with water.

Sodium acetate will dissolve completely and dissociate completely in water to give the ions $Na^+(aq)$ and $CH_3COO^-(aq)$. : $CH_3COONa(s) \xrightarrow{H_2O(l)} CH_3COO^-(aq) + Na^+(aq)$ (2)

The Na^+ ion will be hydrated.



(2)

The CH_3COO^- ion will dissociate weakly to produce OH^- and give a basic aqueous solution according to the following equation:

(3)

$$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$$

Overall, the solution produced will be basic. The Na^+ ion is a spectator ion.

(g) A 2.89-g sample of $NH_4Cl(s)$ is dissolved in pure water to give 60.00 mL of solution. Then 20.00 mL of this solution is added to 13.48 mL of 0.750 *M* $NH_3(aq)$.

Calculate the pH of the final solution.

$$n_{NH_4Cl} = \frac{m}{M} = \frac{2.89\,g}{53.49\,g/mol} = 0.0540\ mol$$

$$\therefore C_{NH_4Cl} = \frac{n}{V} = \frac{0.0540\ mol}{60.00\times10^{-3}\,L} = 0.900\ mol/L \quad (2)$$

$$\underset{0.900\ mol/L}{NH_4Cl(aq)} \longrightarrow \underset{0.900\ mol/L}{NH_4^+(aq)} + Cl^-(aq)$$

Buffer solution: $NH_4^+ \Rightarrow n = CV = 0.900\ mol/L \times 20.00\times10^{-3}\,L = 0.0180\ mol$

Total volume $= 20.00\ mL + 13.48\ mL = 33.48\ mL$

$$\therefore C_{NH_4^+} = \frac{0.0180\ mol}{33.48\times10^{-3}\,L} = 0.538\ mol/L \quad (2)$$

$NH_3 \Rightarrow n = CV = 0.750\ mol/L \times 13.48\times10^{-3}\,L = 0.0101\ mol$

$$\therefore C_{NH_3} = \frac{0.0101\ mol}{33.48\times10^{-3}\,L} = 0.302\ mol/L \quad (2)$$

$pK_b(NH_3) = -\log(1.78\times10^{-5}) = 4.750$

$\therefore pK_a(NH_4^+) = 14.00 - 4.750 = 9.25 \quad (2)$

$$\therefore pH = pK_a + \log\frac{[NH_3]}{[NH_4^+]}$$

$$pH = 9.25 + \log\frac{(0.302)}{(0.538)} \Rightarrow 9.25 - 0.251 = \underline{9.00} \quad (2)$$

What do you think will happen if a drop of 0.500 *M* NaOH(*aq*) is added to this solution? Explain.

The buffer solution will resist a change to the pH of the solution. The hydroxide ion added will be removed by the NH_4^+ ion which is present in large quantities. The pH of the solution will increase by a small amount

(2)

(h) A student diluted 10.00 mL of a solution of an unknown organic acid to get 50.00 mL of 0.0400 *M* of the final solution.

(i) What was the molarity of the original solution?

(2)

$C_iV_i = C_fV_f$

$10.00 \times 10^{-3} L \times C_i = 50.00 \times 10^{-3} L \times 0.0400 \text{ mol/L}$

$\therefore C_i = 0.200 \text{ mol/L}$

(ii) Without drawing any diagrams, describe exactly what the student did in the laboratory to $\boxed{\text{dilute the solution.}}$

(4)

The student transferred 10.00 mL of the original solution with a 10-mL pipette to a 50-mL volumetric flask. Then distilled water was added the volumetric flask until the meniscus reached the calibration mark. Then the mixture was shaken and swirled to homogenize it.

(iii) If 25.00 mL of the final solution of the organic acid requires 20.00 mL of 0.0750 *M* $Ba(OH)_2(aq)$ to reach the equivalence point in a titration, what can you conclude about this organic acid?

(5)

Organic acid

$H_xA(aq)$	+	$Ba(OH)_2(aq)$
$C = 0.0400$ mol/L		$C = 0.0750$ mol/L
$V = 25.00 \times 10^{-3} L$		$V = 20.00 \times 10^{-3}$ mol
$n = CV = 1.00 \times 10^{-3}$ mol		$n = 1.50 \times 10^{-3}$ mol

mole ratio of H_xA to $Ba(OH)_2$

$\Rightarrow 1.00 \times 10^{-3} \text{ mol} : 1.50 \times 10^{-3} \text{ mol}$

$2 : 3$

$\therefore H_xA$ is triprotic